Docket No.: S4-03P09159

CERTIFICATION

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English and German languages, and that I believe that the attached text is a true and complete translation of PCT/EP2004/051634, filed with the European Patent Office on July 28, 2004.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Hollywood, Florida

Rebekka Pierre

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Lerner Greenberg Stemer LLP
P.O. Box 2480
Hollywood, FL 33022-2480
Tel.: (954) 925-1100
Fax.: (954) 925-1101

Description

Electronic unit and method for manufacturing an electronic unit

The present invention relates to an electronic unit, in particular a control device for a motor vehicle, comprising at least one printed circuit board which is populated with electronic components and a housing that encloses the printed circuit board. Furthermore, the invention relates to a method for manufacturing such an electronic unit and to a use of such an electronic unit.

In the field of motor vehicle electronics, control devices for controlling electrical and electronic vehicle components (e.g. engine control devices) are well known, the circuit board (circuit carrier) being manufactured by means of thick-film technology or laminate technology in order to achieve greater temperature stability.

In the case of thick-film technology, provision is made for a relatively thick ceramic substrate with likewise relatively thick fired-on conductor paths, for example. This has clear cost disadvantages, since the manufacturing of such a printed circuit board is significantly more expensive than the manufacturing of a simple printed circuit board (e.g. comprising a thin epoxy substrate).

In the case of laminate technology, a conventional printed circuit board is combined with a metal layer to form a laminate by applying a high pressure and a high temperature, for example. This is disadvantageous in that the printed circuit board which is manufactured using laminate technology can only be populated with electronic components on one side, and therefore the surface requirement in a predetermined electronic circuit arrangement is greater in comparison with conventional

printed circuit boards which are populated on both sides. Avoiding the increased surface requirement by arranging two or more printed circuit boards one above the other, for example, is often unsatisfactory since the construction space and the assembly costs are increased in this case.

In general, it is important in many application scenarios to implement an efficient heat dissipation from the electronic components to the housing, in particular if e.g. active semiconductor power components are used in the electronic unit and/or the electronic unit will be used in an environment featuring comparatively high ambient temperature. This applies in the case of control devices for vehicles, for example, which control devices are arranged in the vicinity of or directly at an internal combustion engine, e.g. in order to simplify the wire harness configuration of the vehicle or in order to allow the engine to be electronically tested together with the associated control device in a simple manner. The above cited thick-film technology or laminate technology are usually used for the known control devices which are installed close to the engine.

The invention addresses the problem of improving an electronic unit of the type cited at the beginning in respect of heat dissipation properties and in respect of manufacturing costs.

This problem is solved by an electronic unit as claimed in claim 1 and a method for manufacturing an electronic unit as claimed in claim 11. The dependent claims relate to advantageous developments of the invention.

The electronic unit according to the invention includes at least one printed circuit board section which is arranged at a distance from the housing and is populated on both sides with electronic components. This or these printed circuit board

sections are subsequently designated as "first printed circuit board section(s)". The printed circuit board also includes at least one printed circuit board section which is connected to the housing via a heat-conducting adhesive layer. This or these printed circuit board sections are subsequently designated as "second printed circuit board section(s)". In the case of a multipart housing, this bonding to the second printed circuit board section or sections can occur at any of the housing parts. As a result of the partially two-sided component mounting (on the first printed circuit board section, of which there is at least one), there is a comparatively smaller surface requirement, particularly if the portion of the first printed circuit board section or sections represents at least 30% of the total printed circuit board surface. Furthermore, the second printed circuit board section advantageously acts as both a mechanical and thermal "interface" to the housing, which should be considered in this regard as both a mechanical base and a heat sink. According to the invention, the connection via an adhesive layer makes the design of this dual-purpose interface very efficient, favorable in terms of manufacturing, and economical in terms of space.

For the sake of simplicity, reference is only made to the first printed circuit board section or second printed circuit board section in the following, even though a plurality of such sections can be provided in each case. The explanations which are provided for such a printed circuit board section can then readily be applied to more than one or all of the relevant plurality of printed circuit board sections.

That side of the second printed circuit board section to which the adhesive layer is applied is preferably provided with a metal surface (extended conductor path), in order to achieve horizontal heat spreading and good thermal connection to the adjoining adhesive layer. That side of a second printed circuit

board section which is opposite to the adhesive layer is highly suitable for fitting with electronic components which produce particularly large amounts of heat, since this heat can be transferred via the nearby underlying adhesive layer which has little heat transmission resistance, in particular via heat-conducting metallized through openings ("vias") which are arranged at this position.

The adhesive is preferably applied as liquid adhesive and then cured. The curing of the adhesive can easily be performed thermally. For good heat dissipation efficiency, the use of an adhesive having a thermal conductivity of at least 0.5 W/mK, in particular at least 1 W/mK, is preferred.

The adhesive layer connection between the printed circuit board and the housing makes it possible to dispense with the screw connection which is usually provided in conventional electronic units for the purpose of fastening. If the electronic unit has a plurality of printed circuit boards which are stacked in parallel with each other, the further printed circuit boards can likewise be fastened inside the housing by means of bonding and/or conventional screw connection, e.g. using suitable spacers.

In an embodiment, the housing comprises a housing floor and a housing cover which is connected thereto. This has the advantage that the manufacturing of the electronic unit can be done in a simple manner by initially gluing the already populated printed circuit board into place in one of these housing parts and then closing the housing by connecting between housing floor and housing cover. For good heat dissipation through the housing, it is advantageous if the entire housing or at least that part of the housing which is thermally connected to the printed circuit board via the adhesive layer is made of a material offering good thermal

conductivity such as, for example, metal (e.g. aluminum alloy).

In a preferred embodiment, the housing floor includes cross-sectional indentations for providing housing internal sections that are used for connecting to the second printed circuit board section via the adhesive layer, there being at least one such second printed circuit board section.

A connection between housing floor and housing cover, which connection is simple in terms of manufacturing, can be implemented by means of a glued groove-and-projection connection. In particular, the adhesive which is in any case required for the connection between printed circuit board and housing can be used for this purpose. The housing internal space can be effectively protected against contamination by means of a structure in which an annularly continuous projection running around the edge of a housing part (floor or cover) engages in a correspondingly arranged groove in the other housing part.

In particular, for a low construction height of the electronic unit, it is beneficial to integrate at least one electrical plug connector in the housing cover in order to provide an electrical connection possibility. According to the invention, terminal pins of the plug connector can run straight to the printed circuit board which is adjacent to the housing cover, and can be contacted directly onto this printed circuit board. In particular, in the case of this straight terminal pin alignment, the contacting can be provided easily in the form of press-in contacting, e.g. by placement of the housing cover which is equipped with the plug connector or connectors onto the housing floor when the housing is closed.

The specific arrangement of the second printed circuit board section or sections (considered in the plane of the printed

circuit board) has a bearing on the fastening and the heat dissipation properties. In this context, it has proven beneficial if at least two second printed circuit board sections are provided, whose minimal reciprocal distance is greater than 40% of a maximal printed circuit board extent. This is primarily advantageous for stable storage of the printed circuit board which is mounted at the second printed circuit board sections. Irrespective of this, it is beneficial if at least one of the second printed circuit board sections is arranged at a printed circuit board edge. Finally, it is also beneficial in this respect if at least one of the second printed circuit board sections runs along a large part of a printed circuit board edge, and particularly in an annularly continuous manner along a printed circuit board edge. Such an annular connection of the printed circuit board to the housing holds the printed circuit board in a particularly stable manner and results in a particularly uniform heat dissipation during operation of the electronic unit.

Where the printed circuit board side which is opposite to the adhesive layer is not populated with electronic components in a first printed circuit board section, this location is suitable for arranging a conductor path surface which acts as a heat spreading surface and can efficiently dissipate the accumulated heat to the underlying adhesive layer.

A simple method for manufacturing the electronic unit can include, for example, the following steps:

- providing the already populated printed circuit board,

- providing a contoured housing floor having raised housing internal areas and having a groove which runs around the edge of the housing floor,

- depositing liquid adhesive to the raised housing floor areas and to the base of the groove,

- pressing on the printed circuit board in order to bond said printed circuit board onto the raised housing floor surfaces,

- providing a housing cover having a projection which is suitable for engaging in the housing floor groove, and

- pressing the housing cover onto the housing floor in order to create a glued groove-and-projection connection between housing floor and housing cover and in order to contact terminal pins of the plug connector arrangement via press-in technology.

The plug connector arrangement can be contacted to the printed circuit board, e.g. after the printed circuit board has been populated, by means of press-in technology before the printed circuit board is bonded. Alternatively, for example, it is possible for the plug-connector arrangement to be integrated in the housing cover and pressed on together with the housing cover.

The invention is described in greater detail below with reference to an exemplary embodiment and with reference to the attached drawings, in which:

Fig. 1 shows an exploded view of a control device for a vehicle,

Fig. 2 shows a sectional view of the control device in the assembled state in longitudinal section, and

Fig. 3 shows a sectional view of the control device in the

assembled state in cross section.

The Figures 1 to 3 show a control device for a vehicle, said control device having the overall designation of 10. The control device 10 is formed from a rigid printed circuit board 12 (e.g. epoxy substrate with copper conductor paths or surfaces), said printed circuit board being populated with electronic components, and a housing which encloses this printed circuit board, said housing being designed in two parts and comprising a housing floor 14 (base plate) and a housing cover 16. For the electrical connection of the control device to the vehicle electronics of the relevant motor vehicle (e.g. to a test device), provision is made for two plug connectors 18, 20 which, for the purpose of contacting, are placed on the upper side of the printed circuit board 12 in the illustrated exemplary embodiment by means of press-in technology during the assembly of the control device and are screwed to the housing floor 14. For this purpose, the plug-connector housings are provided with fastening screws 22 which, in the assembled state, pass through openings 24 in the printed circuit board 12 and are screwed into corresponding fastening holes 26 in the housing floor 14. The plug connectors 18, 20 pass through suitably dimensioned through openings 28 of the housing cover 16 towards the exterior.

The housing floor 14, which like the housing cover 16 is made of an aluminum alloy, has a shape that is contoured in such a way that a coherent, approximately rectangular, deepened housing internal section 30 is produced in the central area of the floor 14, said section being contiguous around its edge with a raised housing internal section 32.

Corresponding to this arrangement of deepened and raised housing internal sections 30, 32, the printed circuit board 12 has a coherent central printed circuit board section 34 (first

printed circuit board section) which in the assembled state is arranged at a certain distance from the housing floor and which is populated on both sides with electronic components, whereas the printed circuit board 12 has an outer printed circuit board section 36 (second printed circuit board section) which runs in an annularly continuous manner along the printed circuit board edge and whose underside is directly connected to the raised housing internal section 32 via a heat-conducting adhesive layer 42 (Fig. 2 and 3).

This partial connection of the printed circuit board 12 via the adhesive layer 42 guarantees a reliable mechanical retention of the printed circuit board 12 and moreover acts as an efficient dissipation path for heat which is produced by the electrical components during the operation of the control device 10. The adhesive has a thermal conductivity of approximately 2 W/mK. Consequently, the control device 10 is suitable in particular for installation close to the engine in a motor vehicle, since the described structure can cope well with the harsh environmental conditions in terms of mechanical stresses (e.g. vibrations) and temperature.

The illustrated engine control device 10 involves the use of a number of active power semiconductor components, e.g. in a circuit area for DC/DC step-down conversion of an on-vehicle voltage for supplying a circuit part for digital signal processing, or in a circuit area for DC/DC step-up conversion for supplying a circuit part for controlling a fuel injector arrangement of the internal combustion engine. These electronic power components are generally arranged on the upper side of the outer printed circuit board section 36, since an efficient heat dissipation away from this section downwards through the adhesive layer 42 to the housing is possible.

The plug connectors 18, 20 which are used in the illustrated

exemplary embodiment have terminal pins which run straight downwards and can be pressed into correspondingly dimensioned contact holes in the printed circuit board 12 ("press-fit" technology), thereby offering ease of manufacturing. The use of such non-bent terminal pins has a further advantage in that the plug connectors 18, 20 can be integrated in the housing cover 16 (either before or after the housing is closed), this being beneficial with regard to the base surface of the control device 10, and not integrated in a housing side wall area as often occurs in the case of conventional control devices and thereby unnecessarily increases the base surface of the housing. Finally, the contacting of the terminal pins in the central printed circuit board section 34 has the advantage that the conductor paths of the printed circuit board 12 which lead from electronic components to the terminal pins can be arranged comparatively simply in the sense of a less complicated circuit board layout. In particular, the course of the conductor paths between individual components and individual terminal pins tends to be shorter and more direct. By contrast, the printed circuit board layout is more costly and less compact in terms of the required printed circuit board surface when contacting is provided at the edge area of the printed circuit board, as is often the case in conventional control devices with angled plug-connector terminal pins. With regard to the heat dissipation properties of the described control device 10, the centrally-oriented arrangement of the plug connectors 18, 20 is moreover also advantageous in that the terminal pins, which dissipate rather than generate heat, are arranged in that printed circuit board section (34) which is less efficiently cooled than the outer printed circuit board section 36, and in that the terminal pins do not require any printed circuit board surface in the efficiently cooled outer printed circuit board section 36, this being preferably used for fitting with components that generate significant heat (e.g. power transistors).

When assembling the control device 10, a liquid adhesive (e.g. silicone-based) is applied to the raised housing internal section 32 and to the base of a groove 38 which runs around the housing floor 14. The already populated printed circuit board 12 is then positioned in the housing floor 14 and placed on the adhesive layer. The plug connectors 18, 20 and their terminal pins are then contacted to the printed circuit board 12 using press-in technology and fastened by means of the fastening screws 22. In the illustrated exemplary embodiment, the screwing of the plug connectors 18, 20 acts as an additional (not necessary per se) fastening of the printed circuit board 12 in the housing floor 14. Finally, the housing cover 16 is emplaced from above in such a way that an extending projection 40 which runs around the edge of said cover engages in the groove 38 and is bonded thereto. Alternatively, the plug connectors 18, 20 can be attached to the upper side of the printed circuit board first. If a groove is provided around the plug connectors, the connection between the plug connectors 18, 20 and the housing cover 16 can also be implemented advantageously by means of a groove-and-projection bond.

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